

### The Resource

Molluscan shellfish of particular significance in South Carolina include the Eastern oyster, *Crassostrea virginica* and the hard clam, *Mercenaria mercenaria*. These two species are harvested both commercially and recreationally in coastal waters. There is also a clam mariculture industry in the state that produces clams year-round.

In addition to their harvest value, oysters are ecologically significant in South Carolina, because they form complex living reefs that directly and indirectly support a host of other organisms associated with living oysters and dead shell. Many of these plants and animals are generally not abundant in the surrounding sand or mud habitats. Oyster reefs also have important direct and indirect effects through their tremendous processing capacity as filter feeders, removing sediments and other particulate matter from the overlying water column.

The South Carolina Department of Natural Resources (SCDNR) collects fishery-dependent and fishery-independent data on both clam and oyster resources in order to monitor the status of those resources and make effective management decisions to maintain sustainable populations. Fishery-dependent data consist of licensing, permitting and commercial harvest information and are thus limited to those grounds that are available for commercial harvest. Fishery-independent data are collected by the SCDNR through monitoring and research activities and include information on both recreational-only harvested areas as well as commercially- and recreationally harvested areas. SCDNR also conducts studies in areas that are either 'undesignated' or are not open to harvesting, but which contain ecologically significant oyster resources.

This report summarizes the status of South Carolina's oyster and clam resources for the period September 2002 through September 2003 and evaluates trends in these economically valuable species over time.

### Habitat, Biology and Distribution

#### Oysters

The eastern oyster is found from the St. Lawrence River, Canada, to the Atlantic coast of Brazil, including the Gulf

of Mexico. Throughout most of this range, oysters are primarily subtidal, but in South Carolina, Georgia and parts of North Carolina and Florida, oysters occur primarily in the intertidal zone (Figure 1), which is that portion of the shore that is exposed once or twice each day at low tide.



Figure 1. Typical fringing oyster habitat along SC's marsh-lined tidal creeks.

Oysters initially mature as males at an early age and then change sex to spawn primarily as females. From May to October, adult oysters (those greater than 1/2 inch in shell height) are stimulated by our warm water temperatures to release gametes (eggs and sperm) into the water column where fertilization occurs and free-swimming larvae are formed. Oyster larvae float with the currents for up to three weeks before settling to the bottom and cementing permanently to a hard substrate. Once cemented, oysters cannot move (Figure 2). The preferred substrate for larval settle-

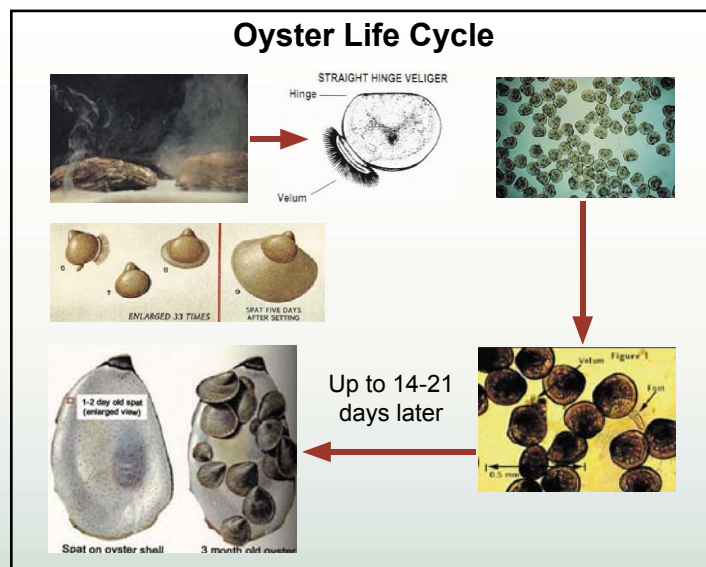


Figure 2. Life cycle of our American or Eastern oyster, *Crassostrea virginica*.

ment is oyster shell, an adaptation that assures the proximity of other oysters, which is essential for successful future reproduction. Thus, dense reefs (Figure 1) are formed by the setting of successive generations of oysters on the shells of their predecessors. In some places, oyster shell can be tens of feet deep or more, but with only the surface veneer representing live animals.

Human activities, in concert with natural phenomena, have greatly affected the distribution and abundance of oysters in the U.S. In many areas, oysters have declined significantly (for example the Chesapeake Bay, North Carolina and Georgia) due to factors such as over-harvesting, physical disturbance, nutrient enrichment through runoff, natural and introduced predators and diseases, alteration of natural flow regimes and salinity patterns, increased siltation, deteriorating water quality, and loss of sufficient clean oyster shell for new recruits. Increased coastal development and associated use or increased harvesting is placing the oyster in jeopardy as a critical habitat and a renewable resource.

Intertidal oyster reefs consist of vertical clusters built upon a fragile matrix of shell (both live and dead oysters) surrounded by fine sediments. Physical disturbance easily disrupts this matrix, undermining the physical integrity of the reef, thereby breaking large clusters into smaller units that cannot stand-up vertically and are more easily washed away. Entire clusters may be dislodged by wind and boat generated waves, with damaged clusters quickly smothered by sediments or washed into the subtidal zone by the wave action. Damaged reefs are even more vulnerable to physical disturbance and the process may accelerate rapidly until the reef essentially disappears.

Intertidal oysters are harvested at low-tide by hand with the use of various tools to pry apart the oyster clusters. Removal of the edible resource simultaneously impacts the habitat, resulting in decreased recruitment and reef structure. Not only is the reef itself disturbed and made more vulnerable to waves, but the natural process of reef replenishment is interrupted by removal of shell critical as settling substrate. Significant harvesting may not be sustainable unless we carefully monitor and regulate harvesting pressure, support good harvesting practices such as "culling in place" and regularly replant shell to offset harvesting.

### Hard Clams

The hard clam is found from the St. Lawrence River, Canada, to the Gulf of Mexico, and has been introduced to other areas of the United States, notably the coasts of California and Washington, to Puerto Rico, and to Great Britain. There are two species in SC waters, *Mercenaria mercenaria* and *M. campechiensis*, but *M. mercenaria* is the

only species that is both abundant and typically harvested in South Carolina.

Hard clams require relatively high salinities and are rarely found where salinities average less than 20 parts per thousand (ppt) (normal seawater is 34 ppt). Hard clams occupy intertidal, as well as subtidal habitats in South Carolina, burrowing into the substrate to various depths (normally less than 8"). They are found in a variety of substrates including sand, mud, shell and mixtures of these. Unlike oysters, clams maintain mobility throughout their lifespan, moving up and down, as well as laterally. Smaller intertidal clams settle in and around oyster reef habitat, probably as a refuge from predators. With age, clams become less susceptible to predation, except by whelk, due to a refuge in size and may move into soft sediments without shell.

Hard clams usually reach sexual maturity at a size of about 1.4 inches in shell length (SL). The sexes are separate, but are externally indistinguishable. Like oysters, clams are mature initially as males and change sex in subsequent years to spawn as females. When stimulated by appropriate environmental conditions (normally high water temperatures), clams release gametes to the surrounding waters. The presence of eggs and sperm in the water stimulates other clams in the immediate vicinity to begin spawning. Fertilization occurs in the water column, producing a free-swimming 'veliger' larva within 24 hours. The length of the larval period is largely dependent on temperature and food supply. After 7-21 days, the larva settles to the bottom and changes drastically into the adult stage. Here in South Carolina, clams usually spawn intermittently from May through October. A female clam can release several million eggs in a single spawning, but only an extremely-small percentage survive the larval period to become juvenile clams. In South Carolina, wild clams grow to marketable size (about 2 inches in length) in 3-4 years, while cultured clams may reach this size in about two years. They are harvested with hand rakes, tongs, bull rakes, forks, or subtidally with hydraulic escalators. Clam harvesting with rakes can significantly disturb the integrity of oyster reefs, where these species co-occur.

### Resource Management

SCDHEC and SCDNR share responsibility for the management and enforcement of harvesting related to all shellfish resources. South Carolina's coastline contains 571,000 acres designated by SC Department of Health and Environmental Control (or SCDHEC) as "Shellfish Growing Waters." In 2003, 166,734 acres (or over 30%) were closed by SCDHEC due to water quality related issues or their proximity to marinas or other marine uses. Harvestable

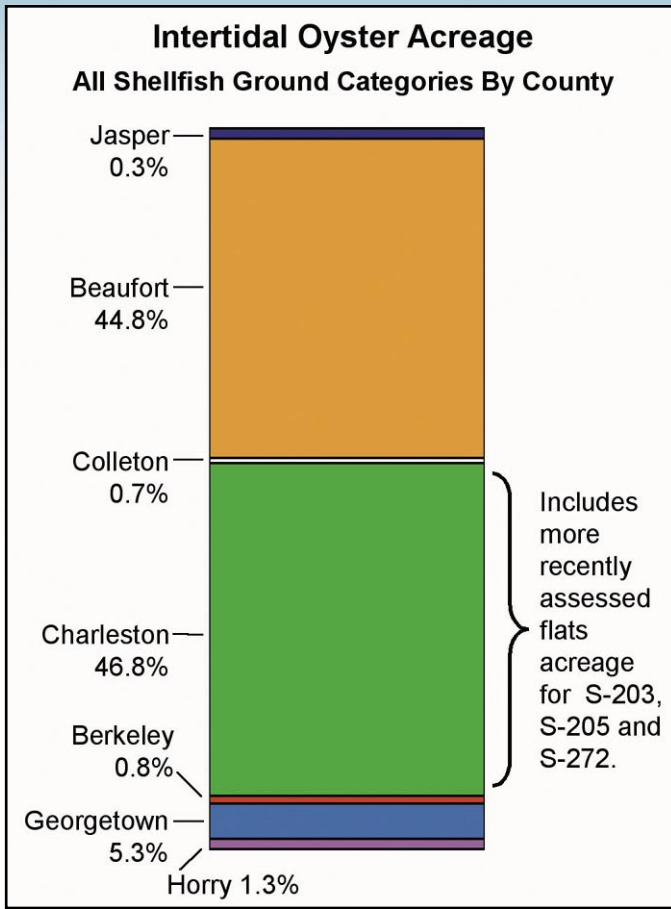


Figure 3. Intertidal oyster acreage by county (All grounds combined).

oyster resources are concentrated in Charleston and Beaufort Counties (> 90%, Figure 3), whereas clam resources have traditionally been concentrated in Charleston and Georgetown counties.

SCDNR staff annually review data on the 'quality' and 'quantity' of the resource and recent trends in landings to decide which state shellfish grounds will be open for commercial and/or recreational harvest of oysters and/or clams. Additional restrictions on harvesting are imposed by SCDHEC, the state agency that has the authority to close grounds where shellfish are considered 'unsafe' for human consumption due to water quality conditions.

SCDHEC staff classify shellfish growing waters based primarily on water quality conditions, as either 'Prohibited', 'Restricted', 'Conditional', or 'Approved'. 'Prohibited' areas are totally closed to shellfish harvesting. These are often closed due to their proximity to marinas and other industries. Direct harvesting from 'Restricted' waters is not allowed, but shellfish may be transferred from these areas to open areas under special permit. 'Conditional' areas are subject to temporary closure, usually following rain events of a certain magnitude. SCDHEC evaluates the status of

shellfish growing areas annually and changes the harvest classification if warranted. From 1986 to 2003, South Carolina's shellfish acreage by DHEC shellfish harvesting classification category (as percent of total) changed little (Figure 4).

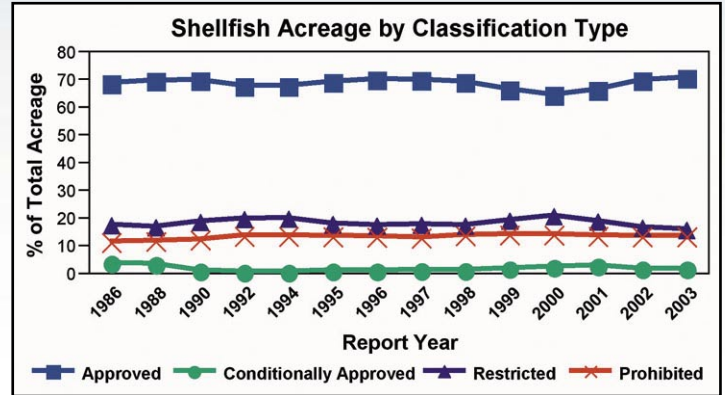


Figure 4. Shellfish acreage by DHEC shellfish harvesting classification category from 1986 to 2003.

For resource management purposes, shellfish areas in South Carolina are classified by SCDNR into three major categories (Figure 5):

- A 'Culture Permit' area is under private management for commercial harvesting. Permit holders pay an annual fee to the SCDNR and must meet certain culture criteria, such as shell replanting, another approved husbandry method or the planting of seed for equivalent credit on the grounds. In 2002-2003, 109 culture permits accounted for approximately 1,800 acres, 75% of which are intertidal, 25% subtidal;
- A 'Public Shellfish Ground' (PSG) is an area set aside for recreational harvesting only. Currently, there are 20 PSGs in the state totaling approximately 100 acres; and
- A 'State Shellfish Ground' (SSG) is an area generally open to both recreational and commercial harvesting, although a few have been designated as 'Recreational-harvesting only'. As of this report, there are 61 designated SSGs encompassing approximately 222 acres. Eighteen SSGs (or 30%) are managed for harvesting clam resources only, while the other 47 are managed for harvesting both oyster and clam resources. (These numbers change slightly each year based on harvest trends and resource assessments). Fifteen of the 61 (or 25%) SSGs are closed to all types of shellfish harvesting by SCDHEC and an additional three are partially closed. Six SSGs are closed to commercial harvest, but open for recreational harvest.



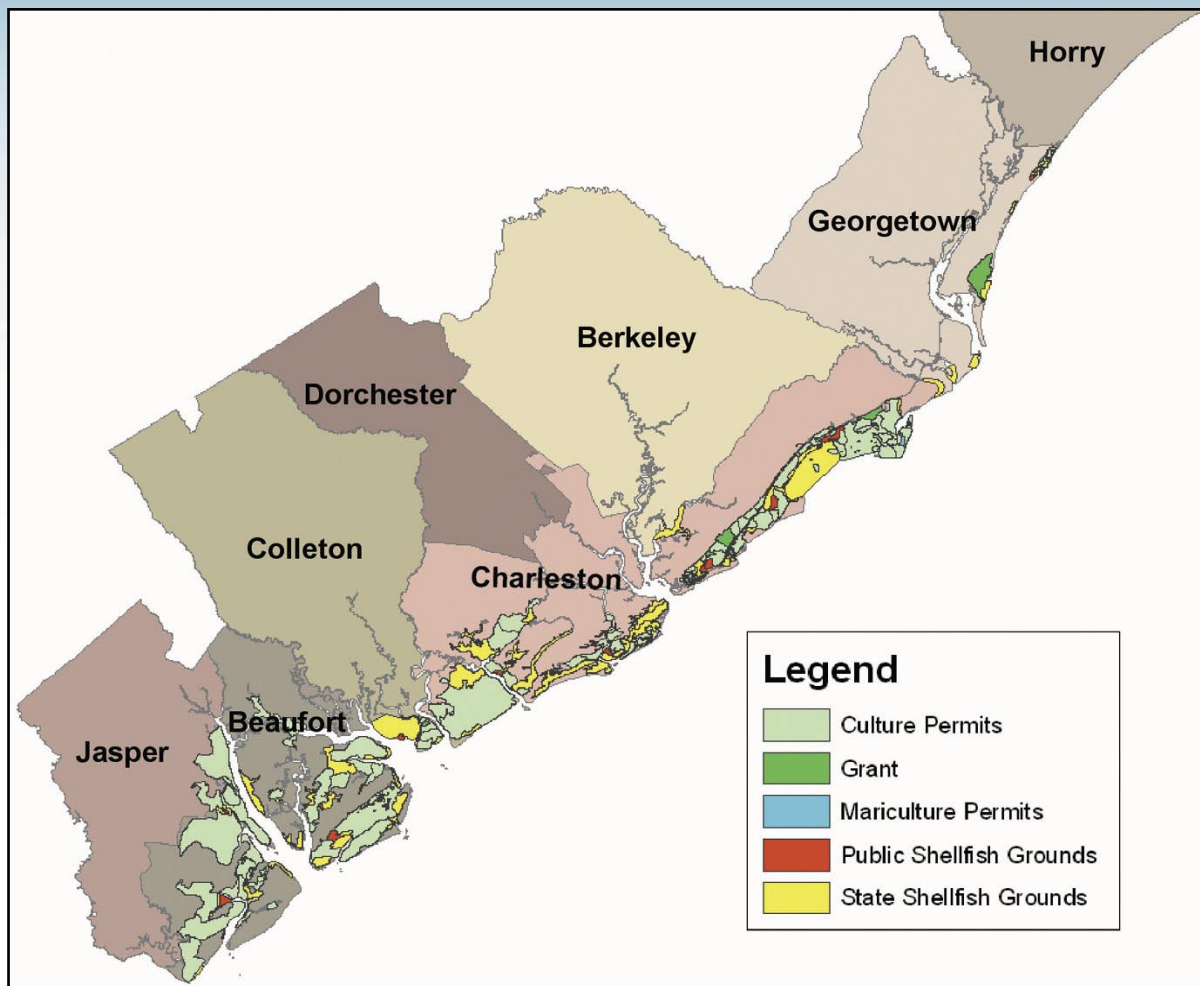


Figure 5. Composite of entire South Carolina coast by shellfish ground type (color coded by type and county).

Two additional categories are ‘*Mariculture Permits*’, which are areas permitted exclusively (as of February 2003) for clam aquaculture, and ‘*Grant Areas*’, which are grounds that are privately held based on ‘*Kings Grants*’ dating back to colonial days and more recent legislative grants. There are nine grant areas along the SC coast, including a large portion of North Inlet, but most of these have not been surveyed to determine acreage of actual oyster grounds. Grant areas convey rights to intertidal shellfish resources but not to subtidal resources. ‘*Mariculture Permits*’ are usually located within the perimeter boundaries of culture permits and State Shellfish Grounds (SSGs) since a Mariculture permit does not convey any rights to naturally occurring resources. 1,856 acres were classified as ‘*Mariculture Permits*’ in 2003. (Table 1).

The harvest season for clams and oysters usually extends from September 15-May 15 each year, but the SCDNR may delay the opening or extend the closing date if conditions warrant. Recreational harvest requires a \$10 Saltwater Recreational Fishing License, issued by the SCDNR on an annual basis. Commercial harvesting requires a commercial saltwater fishing license (\$25). An additional license fee of \$75 is required for commercial harvesting on SSGs.

## Resource Monitoring Methods

### *Fishery-Dependent*

#### Culture Permits/Independent Harvesters

Commercial shellfish harvesters fall into two categories: Culture permit holders, and independent harvesters. Culture permit holders must apply to the SCDNR for rights to a particular shellfish ground (\$25 application fee). If approved, fees are based on actual acreage of shellfish resource (\$5 per acre of resource). Culture permit holders are also required to plant shell (50 bushels/lease acre) or an approved alternative on their grounds. Independent harvesters must have a commercial license (\$25). They can then harvest from culture permits with permission (and a sticker) from the culture permit holder or from SSGs with an additional license (\$75) from the SCDNR and a sticker for each SSG to be harvested. Independent harvesters may have no more than five SSG stickers at a time but may turn in stickers and procure different stickers throughout the season.

Table 1. Summary of shellfish grounds by management classification for 2003-04 harvesting season.

### Summary of S.C Shellfish Grounds Through June 30, 2003

Management Classification	Total # of grounds	Total # of Permittees	Acreage	Acreage Type(s) Enumerated
Culture Permits	109	66	1,814	Intertidal oyster footprint and permitted subtidal bottoms (subtidal primarily for clams)
Mariculture Permits	40	19	1,856	Intertidal and subtidal bottoms with few or no naturally occurring shellfish (all permitted for clams)
State Shellfish Grounds	61	N/A	222	Intertidal oyster footprint (seven SSGs designated for subtidal harvesting only, primarily for clams with hydraulic escalators)
Public Shellfish Grounds	20	N/A	100	Intertidal oyster footprint
Grants	9	N/A	N/A	N/A
<b>Total</b>			<b>*3,992</b>	

\* Currently does not include subtidal SSGs acreage, oyster footprint on flats (SSGs) or Grants intertidal oyster footprint

#### Commercial Landings

Commercial shellfish harvests are reported to the SCDNR Statistics Section on a monthly basis by shellfish stock dealers. Data reported include the quantity of shellfish, date of collection and ground from which they were collected. In the past, reports did not include any information that would allow the SCDNR to determine a catch per unit effort based on landings and associated harvesters. However, with the new reporting requirements now in place since September 2003, we will be able to collect 'effort' data. There is currently no way of knowing the recreational harvest of shellfish, although the SCDNR has typically used 50% of the commercial landings as a surrogate for actual data based on an early 'creel' survey.

#### ***Fishery Independent***

##### Annual Post-Season Qualitative Assessments

After the close of the shellfish harvest season each year (usually on May 15), SCDNR staff visit most SSGs to qualitatively assess the status of the oyster and clam resource. Oyster populations are assessed on three attributes: (1) '*Quantity*' which is based on the overall density of oysters on reefs; (2) '*Quality*' which is based on overall shell appearance (evidence of recent growth or color) and relative shell thickness as an indication of 'condition'; and

(3) '*Size*', which is a numerical rating corresponding to an overall visually estimated oyster length. A fourth composite rating is also generated by averaging the three attributes for each SSG. In 2001 MRRI assessed both PSGs and 'recreational-SSGs' following the approach used for commercially-harvested SSGs.

Clam assessments in SSGs are also based on size and density from actual raking of several areas on the ground.

##### Natural Population Assessments

The SCDNR also quantitatively assesses the status of shellfish resources by direct sampling (Figure 6). Random and replicated samples are collected from a mid-intertidal height by excavating all material down to a depth of 3-4". The number of samples is dependent on size of area being sampled, with a minimum of at least five samples taken. These samples are processed to determine the number and size of live oysters. Other information such as the ratio of live:dead shell, a site's disease status, and associated fauna may also be collected.

##### Recruitment and Early Growth

Recruitment and early growth of oysters is assessed state-wide at selected SSGs and PSGs and other relevant sites under study, such as restoration sites. Trays filled with



Figure 6. Assessing the status of shellfish resources by directly sampling natural oyster populations at mid-intertidal heights excavating all material down to a depth of 3-4".

South Carolina oyster shell are deployed in the spring each year in triplicate in the mid-intertidal zone along creeks at selected sites (Figure 7). Sites for deployment are rotated annually to cover a subsample of the state each year. These large trays are retrieved after 9-12 months to assess recruitment among sites and also relative growth. In the laboratory, all live oysters are measured with other relevant data also collected (for example, information on associated crabs and mussels).



Figure 7. Assessing oyster recruitment and early growth by deploying trays of shell across the state each year in the Spring, then collecting these the following Fall.

### Shellfish Diseases

The SCDNR also monitors oyster and clam 'health' by testing for pathogens, which have been known to cause shellfish mortalities. Two oyster protozoan pathogens most studied in South Carolina include Dermo (*Perkinsus marinus*) and MSX (*Haplosporidium nelsoni*). QPX (Quahog Parasite Unknown), a parasite of hard clams, was first observed in the 1950s in New Brunswick, Canada, and was more recently implicated in the mortality of cultured clams in the northeast and mid-Atlantic states. Therefore, QPX

was evaluated by SCDNR personnel in 2003 by collecting samples of 25 wildstock and maricultured clams from producers in Cape Romain and Port Royal Sound.

The incidence and prevalence of the diseases were determined using standard SCDNR procedures. Dermo and MSX infections were rated according to categories established by the SCDNR. QPX infection intensities were categorized based on the number of parasite cells per whole tissue section.

### Oyster Restoration Efforts

Intertidal oyster habitats are now clearly viewed to be critical to the healthy functioning of estuaries. We also know that oysters and fringing marsh habitats form a unique association in the southeast and that we need to evaluate this and also impacts of boat wakes on restoration efforts. Building upon past smaller-scale research efforts, SCDNR staff are using Saltwater Fishing License revenues to expand significantly our oyster restoration/ enhancement efforts on publicly-harvested shellfish grounds (Figure 8).

The overall program objectives are:

- To assist with the design, site selection, planting and monitoring/evaluation of restoration sites and to improve methods through adaptive management;
- To evaluate a variety of approaches using various materials to assess cultivation techniques on public shellfish grounds;
- To evaluate methods to stabilize planted shell against boat wakes, including methods for large-scale plantings to provide shell stabilization/retention using a variety of geotextile meshes; and
- To conduct research aimed at maximizing the SCDNR's return on its own planting operations and contractual planting operations.

In 2002, beds were planted using several approaches, including: planting with shell and covered with mesh vs. no-mesh; use of different shell types; and planting shell in different thickness for one or more subplots at each site. Over 32,000 ft<sup>2</sup> using 12,000 bushels was planted with whelk, local South Carolina oyster shell, Gulf oyster shell, or a mixed assortment at the seven subsites. Approximately half of each area was covered with UV-stabilized mesh to evaluate its utility in stabilizing shell in areas with significant boat traffic or wind-wave impacts.





Figure 8. A barge with oyster shell being deployed using a water cannon is used for many of the Department's shell plantings each year in PSGs supported by the DNR Marine Recreational Fisheries License Program.

#### Small-Scale South Carolina Community Restoration/Enhancement Reefs (SCORE)

Since 2000, the MRRI has conducted a community-based oyster restoration program with the goals of establishing demonstration oyster reefs that could be used for research, while also educating the public, fostering stewardship, and increasing public awareness of the importance and fragility of oyster habitats. Volunteers work with scientists to create oyster habitats (Figure 9) from recycled shells placed in plastic mesh bags, which are laid along intertidal shorelines to form a substrate for juvenile oyster attachment. After construction, volunteers monitor water quality weekly at restoration sites, entering data online at our interactive web-site <http://www3.csc.noaa.gov/scoysters>. Restoration sites are sampled annually to determine oyster abundance, size frequency, and use by other animals.



Figure 9. As part of the SCORE program, volunteers fill and place recycled shell in plastic mesh bags along intertidal shorelines to construct reefs.

#### **MRD's Shell Recycling Program**

Oyster shell to use for resource replenishment is becoming scarce and expensive. In South Carolina, with few shucking houses and no canneries since 1986, there are no large

stockpiles of shells. Most South Carolina oysters are sold in the shell for roasts, thus ending up scattered all over the state in small quantities. Much of the shell ends up in landfills or drive-ways. Recognizing the need to make use of this important resource, SCDNR established an oyster shell-recycling program (Figure 10) in fall 2001 with the opening of seven coastal drop-off sites. Additional sites have been added since then to achieve the current total of fourteen. Locations of drop-off sites can be found at <http://saltwaterfishing.sc.gov/oyster.htm>. SCDNR staff regularly empty the recycling stations and transfer the accumulated shells to one of four holding sites where they are quarantined for 3-6 months before being used in the shell-planting program based on an MRRI study.

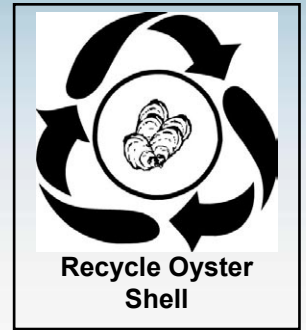


Figure 10. In 2001, SCDNR established an Oyster Shell-Recycling Program with drop-off sites along the State's coastal counties.

## **Findings**

### ***Fishery Dependent***

#### Commercial Permitting and Related Information

During the 2002-2003 harvesting season, 109 areas including 1,870 acres of shellfish grounds were designated as culture permits (Table 1 and Figure 11a,b). Culture Permit holders were credited with planting 94,500 "equivalent U.S. bushels" in either seed oysters, shell, alternative cultch materials or other shellfish cultivation activities (such as raking down/breaking up large clusters of oysters). A portion of these various planting and cultivation activities was done on SSGs or PSGs for double credit toward the culture permit planting requirements. In addition to the culture permit areas, more than 1,400 permits were issued to 256 harvesters for commercial harvest on SSGs in the 2002-03 season. The average number of permits issued over the last 13 years was 1,332 permits and 278 harvesters (Figure 12). The overall value of commercial shellfish harvested (oysters, clams, clam culture) since 1991-1992 is summarized in Figure 13. Note oyster and clam fishery values in dollars have remained fairly stable, whereas clam culture's totals have fluctuated prior to the 1999-2000 season when reporting procedures changed in the state.

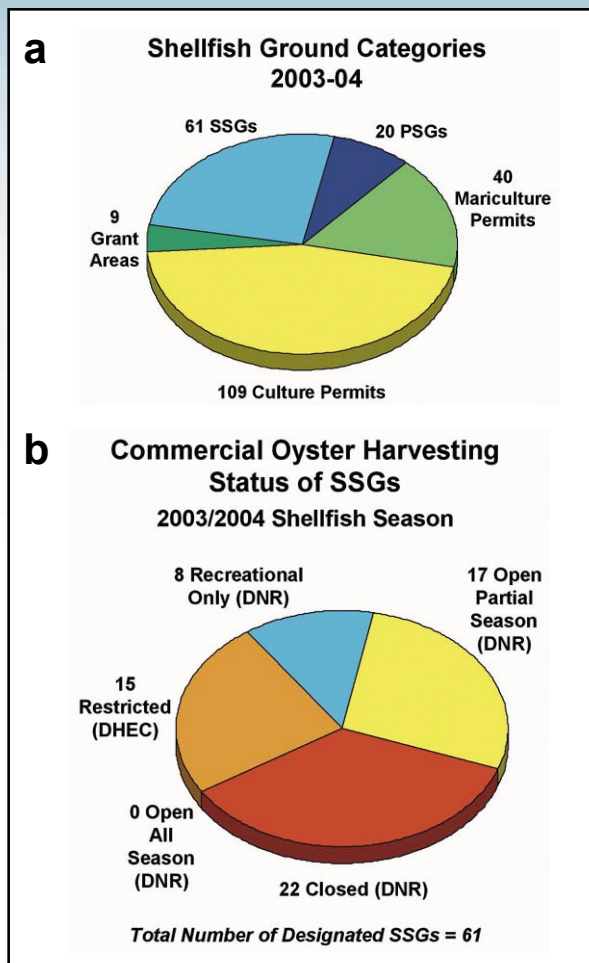


Figure 11. a-Summary of shellfish ground categories for the 2003-04 harvesting season; b-Commercial (SSG) oyster harvesting status for the 61 SSGs during 2003-2004.

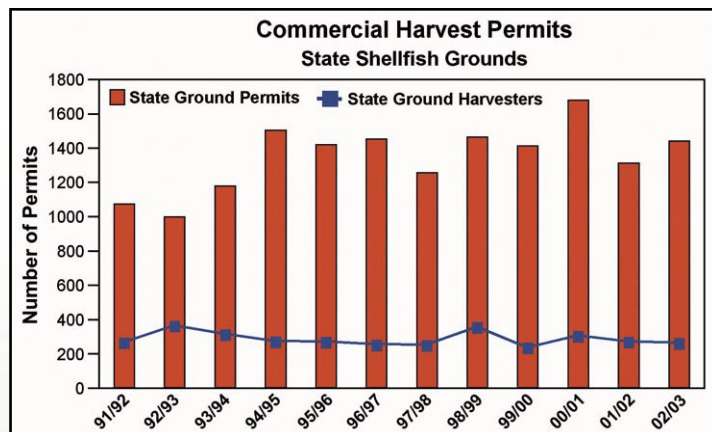


Figure 12. Number of harvesting permits issued on State Grounds (SSGs) and the actual number of commercial harvesters utilizing these permits for harvesting seasons from 1991-92 to 2002-03.

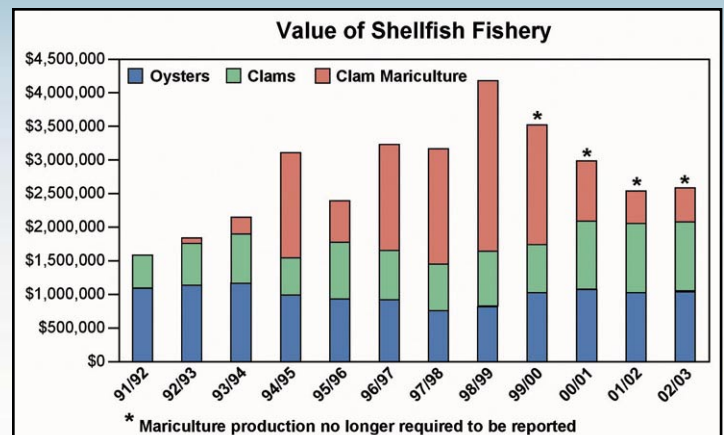


Figure 13. Overall commercial shellfish values in South Carolina since 1991-1992. \*Note, reporting procedures changed for cultured clams in 1999-2000.

### Commercial Landings for Oysters

Total reported oyster landings for 2002-03 were 85,602 U.S. bushels, of which 25,328 were harvested on SSGs. This is more than the 15,951 bushels harvested from SSGs in 2001-02. The reported landings for culture permits were 59,465 bushels, which is approximately 10,000 bushels less than the previous season's landings from culture permits. Total oyster landings have remained fairly steady for the last ten years (Figure 14) although in the 2002-03 season the harvest from SSGs increased and that from culture permits decreased. Over the last ten years, six of the 23 'oyster-producing SSGs' have accounted for over 84% of all of the commercial SSG landings. Adding the next 10 SSGs (total of 16 SSGs) accounted for 97% of all landings since the 1993-1994 season (Figure 15).

### Commercial Landings for Clams

Total reported hard clam landings for 2002-2003 were 39,220 bags (250 count), of which 17,870 bags were harvested from SSGs and 15,991 from culture permits (Figure 15). The remaining landings are from mariculture permits, but only a portion of these landings were reported since as of the 2000-2001 season, mariculture permittees are no longer required to report sales due to changes in regulatory authority. Although the landings for clams appear to be down, this is probably an artifact of the above change in reporting requirements. Landings from SSGs are up slightly compared with previous years.

### Mariculture permits

Forty permits (originally 32, with 8 granted during the season) mariculture permits were in effect in 2002-03. Total acreage designated as 'mariculture permits' declined from



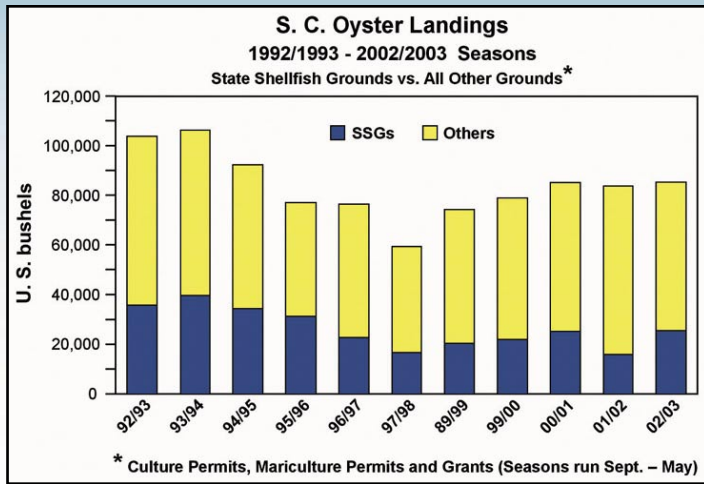


Figure 14. Commercial oyster (*Crassostrea virginica*) landings in South Carolina for the last twelve seasons (1991/92-2002/03) for SSGs and Other Permitting categories.

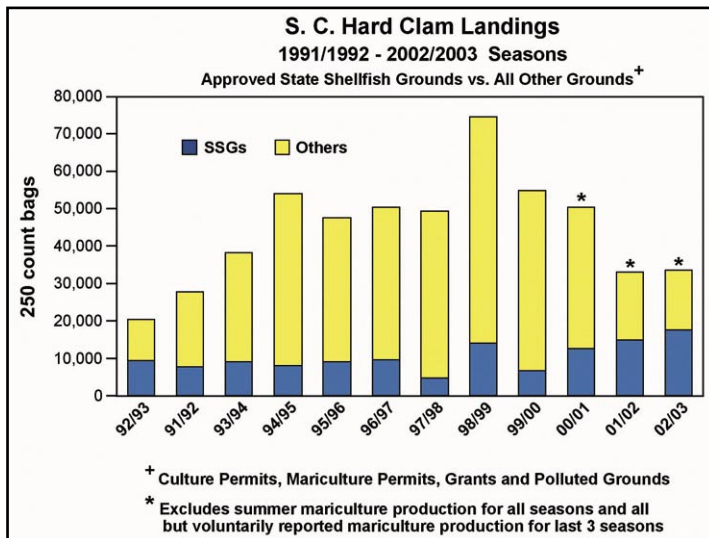


Figure 15. Commercial landings (250 count bags) for hard clams (*Mercenaria mercenaria*) in South Carolina for the last twelve seasons (1991/92-2002/03) for SSGs and Other Permitting categories.

1,886 to 1,856 acres (Table 1, Figure 11a). All of the mariculture permits were for hard clam culture.

### Fishery Independent Data

#### Post-Harvest Assessment, Summer 2003

Post-harvest assessments of SSGs for the last three years are available at <http://www.dnr.state.sc.us/marine/mrri/shellfish/index.htm>. After the close of the 2002-03 harvest season, 35 SSGs were evaluated by SCDNR staff, 23 for both oysters and clams, and 12 for clams only. Eighteen SSGs (13 oyster, 5 clam) had declined in overall 'quality', three (all clam) were unchanged, and 14 (10 oyster, 4 clam)

showed improvement from the previous year. As a result of these surveys and landings data, 12 SSGs were closed to harvesting for the 2003-4 season (seven oyster, four clam) and one Recreational-Only SSG was closed to all harvesting. Of these 12, nine had been open the previous season and three were continuing closures. One of the new closures is the first ever management closure of a 'recreational-only' SSG in Murrells Inlet to allow restoration there. The nine new closures were offset by the opening of seven SSGs (four oyster, three clam), all of which had been closed in 2002-03. Thus, the net effect was that two more SSGs were closed to harvest for 2003-04 than for the previous season. A total of 15 are totally or partly closed by SCDHEC due to water quality or other impacts.

### Natural Oyster Population Sampling

Size frequency information has been collected throughout South Carolina by SCDNR staff for the past eight years to better evaluate oyster population trends. In 2002-03, efforts were concentrated on the May River in Beaufort County as part of a larger study. Oyster density in samples collected over the last eight years (Figure 16) has ranged from 46/ft<sup>2</sup> to 595/ft<sup>2</sup> with an average density of approximately 149/ft<sup>2</sup>. Average oyster sizes ranged from 1" to 2", with overall average size around 1.4". The May River sites sampled in 2003 were average in both density and size of oysters.

### Oyster Recruitment and Early Growth

In 2002-2003, 110 recruitment trays were deployed at 18 SSG/PSG sites and 14 other sites (Figures 17). Recruitment ranged from <100 individuals per m<sup>2</sup> (or 9.3/ft<sup>2</sup>) to a high of almost 8,000 individuals per m<sup>2</sup> (743/ft<sup>2</sup>) and the overall mean recruitment for these sites was 3,300 oysters/

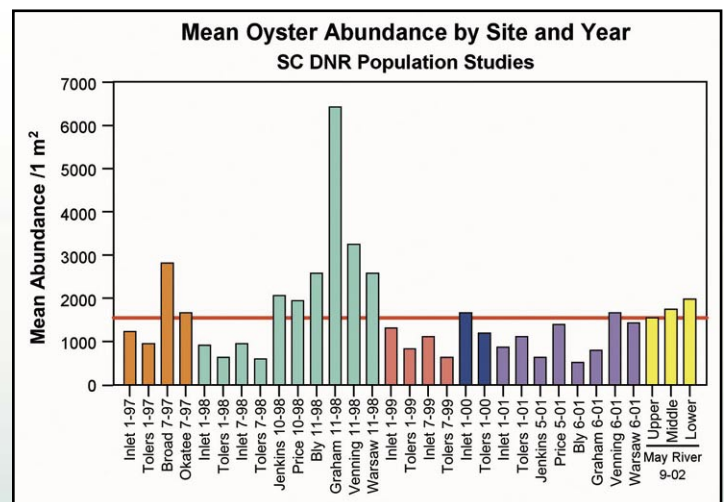


Figure 16. Mean oyster density (# per m<sup>2</sup>) at natural oyster sites sampled over the last eight years. The horizontal orange line is the mean of all the individual site means.

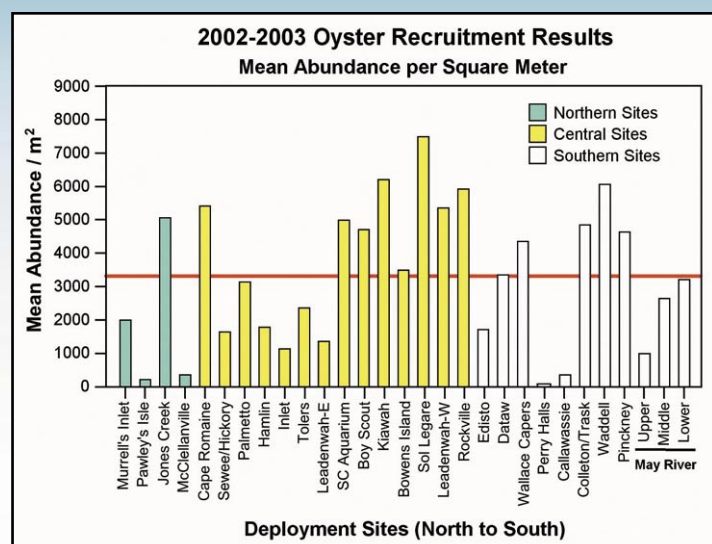


Figure 17. Mean oyster density for recruitment assessments for each site. Horizontal orange line is the overall average across all sites.

m<sup>2</sup> (307/ft<sup>2</sup>). Mean oyster size at the different sites ranged from about 0.34" (approx. 9 mm) to 1.57" (40 mm), with an overall average size of about 1" (25.4 mm).

#### Disease Results (Dermo, MSX and QPX)

Dermo was present at all six long-term study sites during our summer-fall disease assessment in 2003. Overall Dermo intensity levels ranged from a low of 1.64 to 3.28 on a log scale used from 0-6. While 2003 summer/fall Dermo disease levels varied among the six sites, infections (prevalence and intensity) were similar to levels observed previously at these same sites from 1996 and 2001 and slightly higher than those observed in 2002 (Figure 18). MSX infections sampled at the six sites in 2002 and 2003, identified infected oysters at three of the sites, with no MSX observed in the northern most sites in Georgetown or Beaufort Counties. MSX infection levels were lower in 2003 compared to 2002. Since 1996, MSX prevalence levels at the six summer to fall monitoring sites have been moderately low (<20%), with the exception of Price Creek (44%) in 1997. MSX has not routinely been detected in oysters from the northern-most sites.

None of the hard clam tissue samples processed for QPX disease from natural or cultured clams, showed any infections.

#### Oyster Restoration Efforts

##### Large-Scale Salt Water License-Supported Reefs

In 2002, four shell-planting sites were selected along the coast (Figure 19) based on site characteristics and other

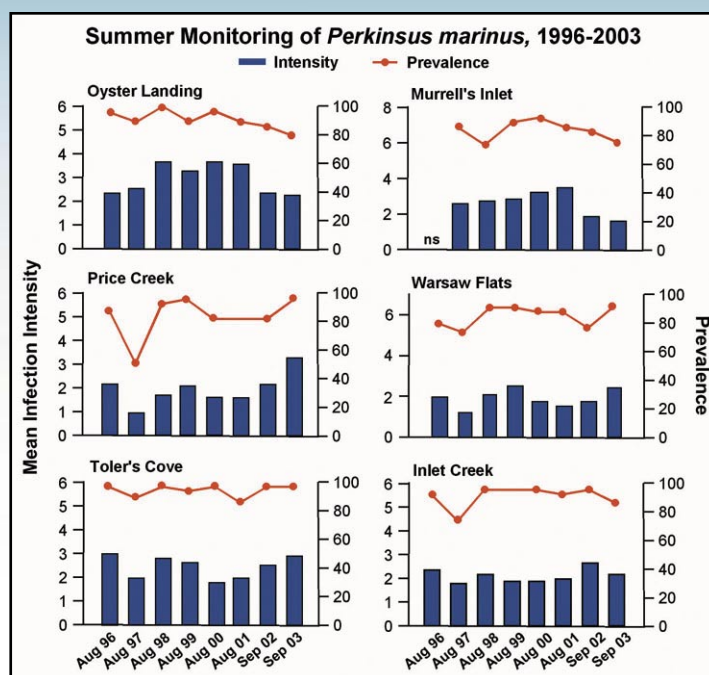


Figure 18. Results of annual Dermo (*Perkinsus marinus*) disease assessment in oysters (*Crassostrea virginica*) at six coastal sites in South Carolina from 1996-2003. Mean prevalence (% with disease) and intensity (level of infection) shown for each site.

criteria. Over 32,000 ft<sup>2</sup> were planted with 12,000 bushels. These were located in Bull Creek, at Pinckney Island, in Murrells Inlet, and in Hamlin Creek. The sites varied considerably in terms of bank slope and sedimentary characteristics. Creek widths and boat traffic also varied considerably, ranging from very wide (>3,300 ft Pinckney site) to relatively narrow (100 ft, Hamlin Creek) or having high (Bull Creek) to relatively little (Murrells Inlet-Clam Bank) boat traffic. Slopes were very important to success when the shell was planted without mesh.

In 2003, a modified approach was employed. Approximately 27,000 U.S. bushels of shell were planted at five sites across the state, covering a total of 86,000 ft<sup>2</sup> (Figure 19). Recruitment at the 2002 reef sites was assessed at approximately one year post-planting in the fall of 2003. Recruitment based on samples collected on the planted reefs was low overall, relative to adjacent deployed trays, with average oyster densities ranging from 219-557/m<sup>2</sup> (20.35 to 51.75/ft<sup>2</sup>). In contrast, oyster densities collected from trays placed next to the reefs ranged from 500-7,000/m<sup>2</sup> (46 to 650/ft<sup>2</sup>), suggesting that larval supply was not the cause of the lower reef numbers. Rather, we can probably attribute the lower densities on sampled reefs to shorter deployment durations and later plantings, since the shell was deployed in August to September, possibly missing most oyster larval recruitment. In contrast, the trays were put out in the late spring.



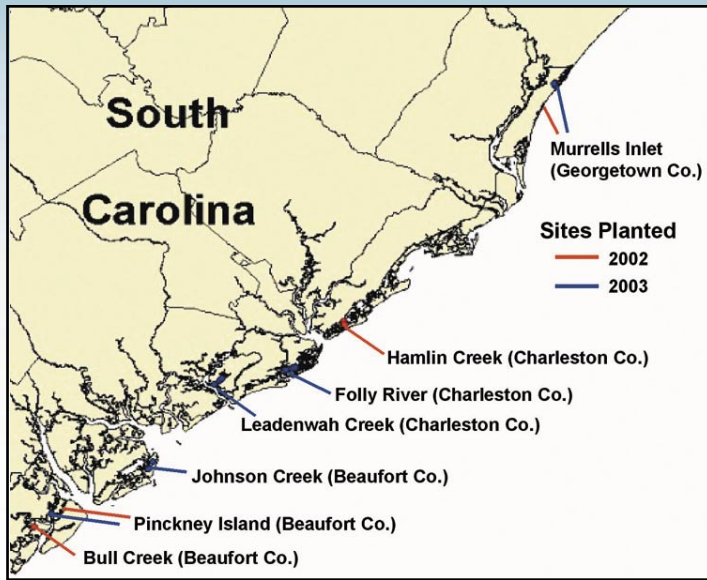


Figure 19. Large-scale restoration sites planted with shell in 2002 and 2003 across the state with DNR Marine Recreational Fisheries License Program funding.

The 2002 sites have shown varying degrees of shell depth change. Sites in the Bull Creek and Hamlin areas have shown an average decrease over the first four months equal to about 2" with an apparent dependence on shell type. Sites planted with the relatively lighter weight South Carolina-derived shell showed the largest decrease in shell depth with an average initial change of 2.8" in Hamlin Creek versus 4.3" in Bull Creek. Whelk and Gulf plantings at these sites decreased less than 1" to 2" initially. Shell depths declined to a lesser extent after initially higher losses when measured every three months. Relatively flat sloped sites, like those at Murrells Inlet and Pinckney Island, have had almost no loss of shell over the recording period.

Sites planted in 2003 have shown lower average decreases in shell depth versus the 2002 sites, perhaps because the 2003 sites were planted on relatively flat slopes compared to the 2002 sites, and they were planted using only whelk, Gulf oyster shell, or some mixture of the two. The 2003 sites have had an average net loss of less than 1".

Changes in the footprint of the planted sites have been quite variable. In 2003, the sites planted at Pinckney had changed very little, whereas a site in Leadenwah Creek increased as much as 15%, probably due to spreading. In contrast, one of the Johnson Creek footprints decreased in area by 75% after only nine months.

### Small-Scale South Carolina Community Restoration/Enhancement Reefs (SCORE)

In the period covered by this report, over 500 volunteers contributed 2,660 hours recycling and bagging shell, monitoring water quality, assisting with reef census, and building new reefs. More than 1,500 volunteers have contributed over 7,000 hours to this project since its inception in 2000. In the summer of 2003 the community-based restoration program built 8,000 ft<sup>2</sup> of oyster reefs at 11 sites (Figure 20), bringing the total reef area built in three years to 5,000 ft<sup>2</sup> at 24 sites along the South Carolina coast. Eight of these sites have reefs of different ages and eight have adaptive treatments incorporated to deal with problem areas.

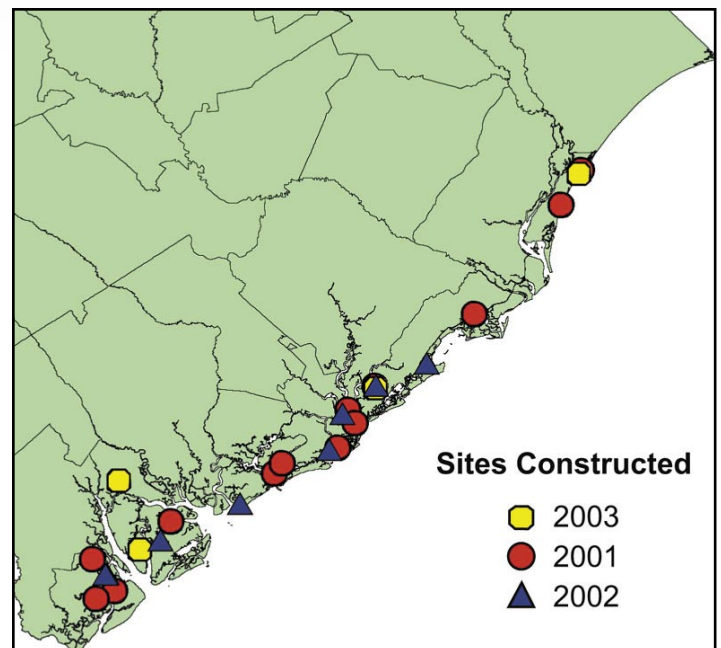


Figure 20. Sites planted with shell bags and monitored by SCORE volunteers from 2001 to 2003 across SC.

In the spring of 2003, 15 sites were sampled to evaluate number and size of new recruits. Recruitment ranged from 105 to 6,605 oysters/m<sup>2</sup> (9.8 oysters/ to 614/ft<sup>2</sup>) with a mean of 2,582 oysters/m<sup>2</sup> (or 240 oysters/ft<sup>2</sup>). This is slightly higher than the mean recruitment of 1,858/m<sup>2</sup> (173/ft<sup>2</sup>) recorded the previous year on SCORE reefs. Average size of the oysters 11-13 months after construction ranged from 0.5" to 1.4" shell height, with an average of less than 1". This is not very different from the previous year's average of 1". An experiment to evaluate recruitment on three different shell substrates (South Carolina oyster, Gulf oyster, and whelk) indicated that there was no difference in recruitment among the shell types. Of the 24 sites constructed to date, seventeen have been censused at least once. As of the census date, which was generally at one year post-construction, thirteen of these reefs had oyster densities greater than



149 oysters/ft<sup>2</sup> (14 oysters/m<sup>2</sup>), which is the general state-wide mean density for natural oyster reefs. Only one site had a density less than 38 oysters/ft<sup>2</sup> (3.5 oysters/m<sup>2</sup>), the mean density recorded on then large-scale restoration sites in Fall 2003.

### MRD's Shell Recycling Program

Additional recycling drop-off sites were opened bringing the state total to 14 in 2003-04. Locations can be found at the recycling website <http://saltwaterfishing.sc.gov/oyster.htm> or by calling (843) 953-9397. Approximately 13,000 bushels of shell were recycled in 2002-2003, which is up significantly from the previous year. Caterers working with the program contribute a large portion of the total. Two groups working with the SCORE program in the Beaufort area also are major contributors. The Beaufort Marine Institute collects shells weekly from several Beaufort restaurants and the Environmental Action Volunteers (EVA) from Sun City collect shells from Hilton Head restaurants. The "MI 2007" group up in Murrells Inlet also collects shell from restaurants in Murrells Inlet area.

### Summary

- A total of 85,602 bushels of oysters and 39,220 bags of clams were landed in the 2002-2003 harvesting season, which is not markedly different than landings in the previous ten years. Monitoring after the 2002-03 harvest season noted 18 SSGs had declined in quality, 3 remained unchanged, and 14 had improved since the previous assessment. Based on this, 11 SSGs were closed to commercial harvest and one recreational-SSG closed to recreational harvest for the 2003-04 season. This is two more than the ten SSGs which were closed in the 2002-03 season. Early recruitment and growth of oysters at the 32 sites, while somewhat lower than the previous year, were within our expectations based on long-term trends and alternation of study sites.
- Disease levels at six sampling sites were comparable to results observed from other South Carolina oyster popu-

lation studies since the 1990s. Dermo prevalence levels were generally >80% at all of the six sites with relatively low disease infection intensities. Historically, Dermo has been present throughout the year in South Carolina and it is unlikely that any South Carolina oyster populations are free of the disease. MSX prevalence during the summer-fall assessments has remained at low levels at all six sites since 1996. QPX is the first known disease associated with hard clam mortality. A small-scale survey of clams in South Carolina did not find evidence of this disease.

- Approximately 12,000 bushels of shell were planted at four sites, covering a total area of 32,000 ft<sup>2</sup>, and 27,000 U.S. bushels were planted at five sites, covering a total area of 86,000 ft<sup>2</sup>. Oyster recruitment was lower on the planted reefs compared to nearby recruitment trays, most probably due to the late plantings of the larger beds compared to when the trays were put out.
- During the 2002-03 oyster season, approximately 13,000 U.S. bushels of oyster shell were recaptured through the shell recycling program, a two to three-fold increase over the number of bushels recycled in the first year of the program. A total of 14 recycling centers were in operation.
- In the period covered by this report, over 500 volunteers contributed 2,660 hours recycling and bagging shell to construct about 8,000 ft<sup>2</sup> of new oyster reefs at 11 sites. Since SCORE's inception in 2000, 1,500 volunteers have contributed more than 7,000 hours to this project, and have constructed a total of 24 new reefs.
- Oyster reefs are important both as a seafood product and as critical habitat that supports many other species. They also improve water quality and can aid in protecting marshes from wind and boat-related erosion.

### Acknowledgments

All of the work included in this summary report was the result of a cumulative effort by numerous personnel in SCDNR-Marine Resources Division. They include: Loren Coen, Nancy Hadley, Yvonne Bobo, Donnia Richardson, Andrew Hollis, Ryan Robol, Jim Monck, Bill Anderson, Mike Yianopoulos, Ray Haggerty, Meghan Ward, Majbritt Bolton-Warberg, Michael Hodges, Jessica Stephen, and many others not listed here.



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# APPENDIX 1. STATE SHELLFISH GROUNDS STATUS

SSG	Geographic Description	County	Intertidal Oyster Acreage	Assessed for C=Clams, O=Oysters	Permitted Species C=Clams, O=Oysters	Assessment Results (1---5)			Harvest Status For Seasons:		
						2001	2002	2003	2001-02	2002-03	2003-04
S-003	Turtle Island	Bft.	N/S	C	C	1.2	2.3	N/A	C	H	O
S-005	Haig Point	Bft.	2.56	O	C; O	1.0	1.7	2.0	C	C	H
S-007	Bull Cr.	Bft.	4.63	O	C; O	2.0	3.3	3.1	C	H	H
S-029	Jarvis Cr.	Bft.	7.86	O	C; O	3.0	3.0	3.2	H	H	H
S-048	N. Hilton Head	Bft.	4.31	C	C	N/A	2.2	N/A	C	C	O
S-058	Chechessee Cr.	Bft.	5.87	O	C; O	N/A	3.3	3.1	C	H	C
S-064	Parris Island	Bft.		C	C	4.5	3.2	3.3	H	H	H
S-064	Parris Island	Bft.		O	O; C	4.0	3.2	2.2	R	R	R
S-065	Morgan Island	Bft.		C	C	1.8	2.7	2.3	H	H	C
S-068	Broad River	Bft.	7.27	O	C; O	3.0	2.3	2.5	H	H	H
S-094	Morse Island	Bft.	1.42	O	C	2.0	2.7	2.0	H	H	H
S-100	Trenchards Inlet	Bft.	2.95	O	C; O	2.8	2.3	2.0	H	H	H
S-101	Station Cr.	Bft.	11.53	O	O	3.2	2.8	2.7	H	H	H
S-106	Old House Cr.	Bft.	1.25	O		2.8	2.5	2.1	C	H	C
S-108	Johnson Cr.	Bft.			O; C	N/A	2.9	N/A	R	R	R
S-117	Distant Island Cr.	Bft.	6.91	O	O; C	2.2	3.5	2.2	C	H	C
S-118	Wallace Cr.	Bft.	16.39	O	C; O	2.2	2.7	3.1	C	C	H
S-124	Morgan River	Bft.	18.48	O	C; O	2.8	3.5	3.2	O	O	H
S-127	Coffin Point	Bft.	N/S	C	C	2.0	4.0	4.0	C	H	C
S-134	Hutchinson Isl.	Coll.		C	C;O	3.0	2.7	3.5	O	O	H
S-135	Ashepoo River	Coll.	Subtidal	-	C	N/A	N/A	N/A	-	-	O
S-140	Pine Island	Coll.	N/S	C	O; C	4.0	4.2	4.0	C	H	H
S-152	Scott Cr.	Chas	1.27	-	-	N/A	N/A	N/A	Closed (DHEC)		
S-161	Steamboat Cr.	Chas	6.32	O	C; O	N/A	2.8	N/A	C	H	H
S-168	Toogoodoo Cr.	Chas	11.24	-	-	N/A	N/A	N/A	Closed (DHEC)		
S-172	New Cut	Chas	0.32	O	C; O	N/A	N/A	N/A	C	O	H
S-182	Leadenwah Cr.	Chas	4.83	O	C; O	N/A	3.2	2.5	O	H	C
S-187	Bohicket Cr.	Chas	7.49	O	C; O	3.5	2.5	2.7	H	C	H
S-189	Snake Island	Chas	DHEC	C	C	2.0	3.0	2.2	C	H	H
S-194	Kiawah River	Chas	6.17	O	C; O	3.0	2.5	2.8	H	H	H
S-196	Cole Cr.	Chas	1.78	O	C; O	1.9	N/A	N/A	R	R	R
S-200	Bird Key	Chas	1.39	O	C; O	NA	2.7	2.3	H	C	C
S-203	Clark Sound	Chas		-	-	3.0	N/A	N/A	Closed (DHEC)		
S-205	Clark Sound	Chas	31.4	O	C; O	3.0	3.2	3.1	H	H	H
S-206	Folly	Chas	N/A	O	C; O	3.0	3.0	3.1	C	H	H
S-929	Charleston Harbor	Chas	Subtidal	-	-	NA	NA	NA	Closed (DHEC)		
S-237	Horlbeck Cr.	Chas	6.31	-	-	NA	NA	NA	Closed (DHEC)		
S-238	Wando River	Chas	16.03	-	C; O	NA	NA	NA	subtidal escalator harvest		
S-242	Seven Reaches	Chas	1.12	C	C	3.7	3.0	3.5	H	H	H
S-251	Swinton Cr.	Chas	3.38	O	C; O	2.5	3.2	2.5	H	C	C
S-255	Lower Hamlin Cr.	Chas	1.02	C	C; O	3.7	3.8	2.8	C	C	H
S-260	Bulkyard Sound	Chas	5.00	C	C	3.8	2.5	3.2	H	H	H
S-262	Capers Cr.	Chas	6.85	O	C; O	3.5	N/A	N/A	R	R	R
S-272	Sewee Bay	Chas	50.76	O	C; O	3.5	3.0	3.1	H	C	H
S-275	Moore's Landing	Chas	0.72	C	C	2.0	4.0	3.0	C	H	C
S-276	S. Bulls Bay	Chas	2.68	O	C; O	3.2	2.3	2.7	H	C	C
S-279	N. Bulls Bay	Chas	10.65	O	C; O	2.5	2.7	3.0	H	H	H
S-280	Sewee Camp Lndg.	Chas	0.03	-	-	N/A	N/A	N/A	Closed (DHEC)		
S-283	Mark Bay	Chas	0.77	C	C	2.0	3.0	3.0	H	H	H
S-286	Bulls Bay	Chas		-	C	N/A	N/A	N/A	H	O	H
S-328	Alligator Cr.	Chas		-	-	N/A	N/A	N/A	Closed (DHEC)		
S-336	South Santee	Chas	Subtidal	-	-	N/A	N/A	N/A	Closed (DHEC)		
S-337	North Santee	Gtown	Subtidal	-	-	N/A	N/A	N/A	Restricted (DHEC)		
S-342	Jones Cr.	Gtown	N/S	O	O; C	2.2	N/A	N/A	R	R	R
S-349	Litchfield South	Gtown	0.32	-	-	N/A	N/A	N/A	Closed (DHEC)		
S-350	Litchfield North	Gtown	2.19	-	-	N/A	N/A	N/A	Closed (DHEC)		
S-354	Brookgreen	Gtown	0.49	O	C; O	2.0	N/A	N/A	R	R	C
S-357	Drunken Jack Isl.	Gtown	1.43	C	C	2.0	2.7	2.7	C	H	C
S-357	Drunken Jack Isl.	Gtown	1.43		O; C			Closed	R	R	R
S-358	Murrells Inlet	Gtown	3.56	C	C	2.7	3.0	N/A	H	C	H
S-358	Murrells Inlet	Gtown	3.56	O	O; C				R	R	R
S-392	Eden Saltworks Cr.	Gtown	N/S	-	-	N/A	N/A	N/A	Closed (DHEC)		

C=Closed O=Open NA=Not Assessed R=Recreational only H=Open half of season